WATER RESOURCES REVIEW for

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CANADA
DEPARTMENT OF THE ENVIRONMENT
INLAND WATERS BRANCH

JUNE

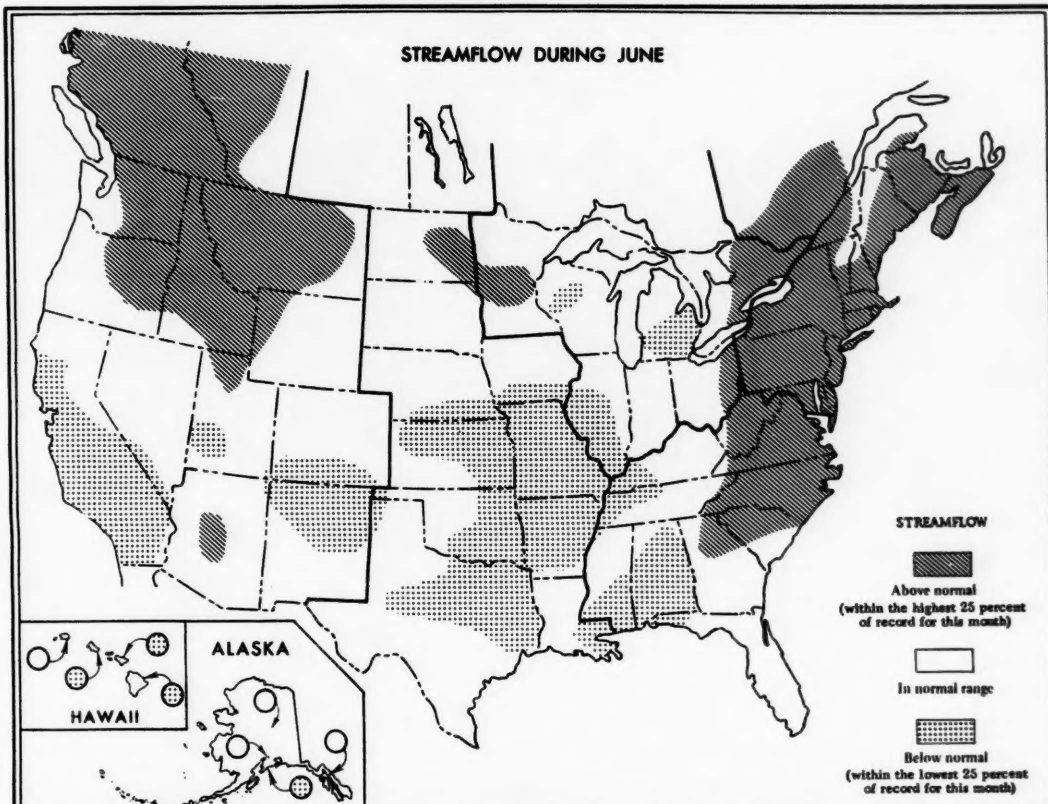
1972

STREAMFLOW AND GROUND–WATER CONDITIONS

Two of the most destructive floods in the history of the United States occurred during June. The one on June 9 and 10 in the Rapid City area of southwestern South Dakota was particularly tragic in terms of lives lost—more than 200. The flood resulted from torrential rains in the Black Hills, causing Rapid Creek to flow at rates not likely to be exceeded more than once (on the average) in 200 or more years.

The most destructive in terms of property damage—estimated at more than one billion dollars in Pennsylvania alone—was caused by tropical storm Agnes and reached its height between June 21 and 24; this flood in the East was also one of the most widespread in history, affecting large parts of a 10-State area. Streams crested at their highest stages and discharges in more than one hundred years in parts of New York, Pennsylvania, Maryland, and Virginia. The Susquehanna River at Harrisburg reached a peak discharge on June 24 that was the highest in at least 185 years. More than 130 lives were lost. Cities suffering especially great damages included Harrisburg, Wilkes-Barre, and Pittsburgh, Pennsylvania; Corning, Elmira, and Wellsville, New York; and Richmond and Roanoke, Virginia.

Floods also struck many other areas in the United States and southern Canada, with streams flowing at new record-high rates for June in parts of Alberta, British Columbia, Washington, Idaho, Montana, and Wyoming. Flooding of two islands in the Sacramento-San Joaquin delta area of California on the 21st was caused by sudden rupture of a levee under repair. In south-central Arizona, widespread flooding occurred in residential sections of Scottsdale and Phoenix.



RECORD-BREAKING FLOODS HIT FOUR EASTERN STATES IN LATE JUNE

Tropical storm Agnes brought death and devastation from floodwaters that surged to record-breaking heights in many parts of Pennsylvania, New York, Maryland, and Virginia between June 21 and 24, and also caused severe or moderate flooding in parts of six adjacent States. Damage estimates reportedly totaled between 1 and 2 billion dollars; and more than 130 lives were lost. The wide areal extent and great severity of destruction were reminiscent of the major northeastern floods of March 1936 that affected virtually the entire region from the James and upper Ohio River basins in Virginia and Pennsylvania to the river basins of Maine——a consequence of two extraordinarily heavy rainstorms coupled with melting of residual winter snows; at that time the Weather Bureau estimated property damage at $270 million, with 107 lives lost. Flows of many streams in 1936 and 1972 were the highest measured or observed in periods of record exceeding 100 years.

Hurricane Agnes moved northward across the Florida Panhandle on June 19th and became a tropical storm as winds decreased during her further inland march to the north. According to reports of the National Weather Service, the storm poured more than 10 inches of rain on parts of Virginia and north-central North Carolina, averaging 4 to 7 inches over the mountains and Piedmont of North Carolina. Much of east-central Pennsylvania (Susquehanna River basin) was deluged with 7 to 8 inches during a 24-hour period on June 21–22. The upper Genesee River basin in New York and north-central Pennsylvania experienced 2 to 4 inches of rain per day for 3 consecutive days, and the adjacent Chemung (Susquehanna) and Allegheny River basins similarly received heavy amounts. The table below shows weekly totals of rainfall at 15 cities from North Carolina to Connecticut; in this region, most of the rain from tropical storm Agnes fell between June 20 and 22, except in North Carolina and Virginia where rains were heavy also on the 19th. Heavy localized rains on June 16–19, centered on Westchester County, New York, and on adjacent southwestern Connecticut and Bergen County, New Jersey, preceded the rains of tropical storm Agnes.

The flooding caused by the torrential rains of Agnes was the most destructive in U.S. history in terms of property damages. Thousands of people were homeless. Pennsylvania suffered the greatest damages. Among the cities that were most severely hit by floodwaters were Harrisburg, Wilkes-Barre, and Pittsburgh in Pennsylvania; Corning, Elmira, and Wellsville in New York; and Richmond and Roanoke in Virginia. The President declared at least five States to be disaster areas: Florida, Maryland, New York, Pennsylvania, and Virgina.

Peak stages and discharges were at or close to the highest of record on hundreds of streams, and by far the highest of record on some streams. Many of the data are listed on the accompanying tables (pages 4 and 6). The map on page 5 shows the locations of the measurement sites described in the tables. Record-breaking peak discharges included Allegheny River at Salamanca, N.Y. (69 years of record); Genesee River at Portageville, N.Y. (68 years of record); Schuylkill River at Philadelphia, Pa. (highest in at least 104 years); Susquehanna River at Wilkes-Barre, Pa. (highest in at least 108 years); and James River at Cartersville, Va. (highest in at least 94 years). Preliminary estimates indicate that flood discharges on many streams in the four-State region were of a magnitude that is likely to occur on the average of only once in more than 100 years (see table). Many stream-gaging stations were

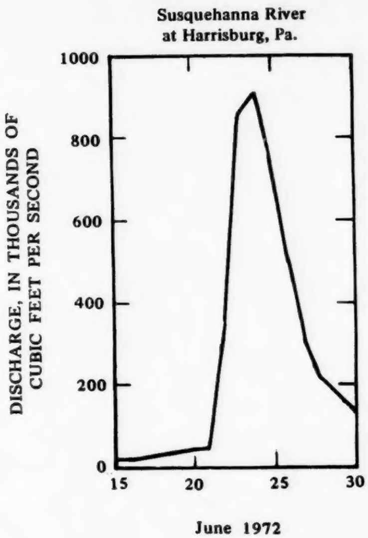
Selected precipitation data from *Weekly Weather & Crop Bulletin* issues dated June 5, 12, 19, and 26, 1972, U.S. Departments of Commerce and Agriculture

State or district	Station	Total precipitation*					
		Week ending June 4 (inches)	Week ending June 11 (inches)	Week ending June 18 (inches)	Week ending June 25 (inches)	4 weeks: May 29–June 25 (inches)	Normal, May 29–June 25 (inches)
Connecticut	Bridgeport	2.8	0.6	4.3	9.3	17.0	3.2
District of Columbia	Washington	1.0	.2	1.1	8.3	10.6	2.9
Maryland	Baltimore	.5	.1	.5	7.0	8.1	3.1
New York	Binghamton	2.1	.2	1.8	5.5	9.6	3.6
	Rochester	1.1	.2	.8	4.2	6.3	2.3
	Syracuse	2.9	1.0	2.4	6.2	12.5	2.7
North Carolina	Greensboro	.9	trace	.1	5.4	6.4	3.2
	Wilmington	.1	.5	.2	5.5	6.3	3.9
Pennsylvania	Allentown	3.6	.1	2.6	4.9	11.2	3.7
	Erie	2.5	.3	1.9	4.6	9.3	2.9
	Harrisburg	1.9	trace	2.0	12.9	16.8	3.2
	Scranton	3.6	.8	1.2	4.4	10.0	3.6
Virginia	Lynchburg	1.4	trace	.2	7.4	9.0	3.6
	Richmond	2.9	.9	4.2	3.3	11.3	3.5
	Roanoke	.4	trace	1.7	4.9	7.0	3.6

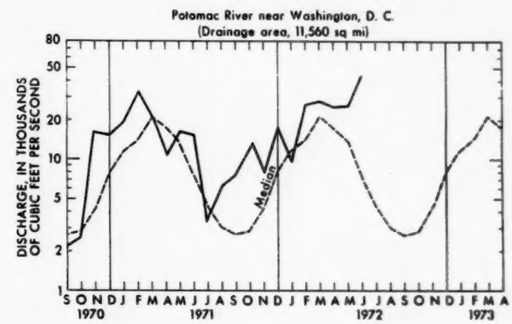
*Based on preliminary reports

inaccessible or destroyed during the maximum impact of the flood, so that indirect measurements and computations are being made at many sites to determine the peak discharges that occurred.

The mean daily discharge for the Susquehanna River at Harrisburg on June 24 was 918,000 cfs—the highest flow in at least 185 years; the momentary maximum occurred at 2 a.m.—about 1,000,000 cfs. The previous highest peak discharge was 654,000 cfs on June 2, 1889. A hydrograph of the Susquehanna River shows the daily flows from June 15 to 30, 1972, including the new daily maximum of record on the 24th. (see below).



Near Washington, D.C., the flow of the Potomac River was fourth highest in at least 83 years of record, exceeded by the floods of June 2, 1889, March 19, 1936 (484,000 cfs), and October 17, 1942 (447,000 cfs). Some lowland park and industrial areas of the city were flooded as the stage at the tide gage (at the foot of Wisconsin Avenue) peaked at 15.4 feet on June 24. The accompanying monthly hydrograph of the Potomac River shows the upward turn in monthly mean discharge for June—reaching 47,000 cfs, more than 6 times the median flow for June during the 30-year reference period 1941–70. The mean daily discharges for June 15–30, 1972, were as follows (note the sharp rise from June 21 to 22):

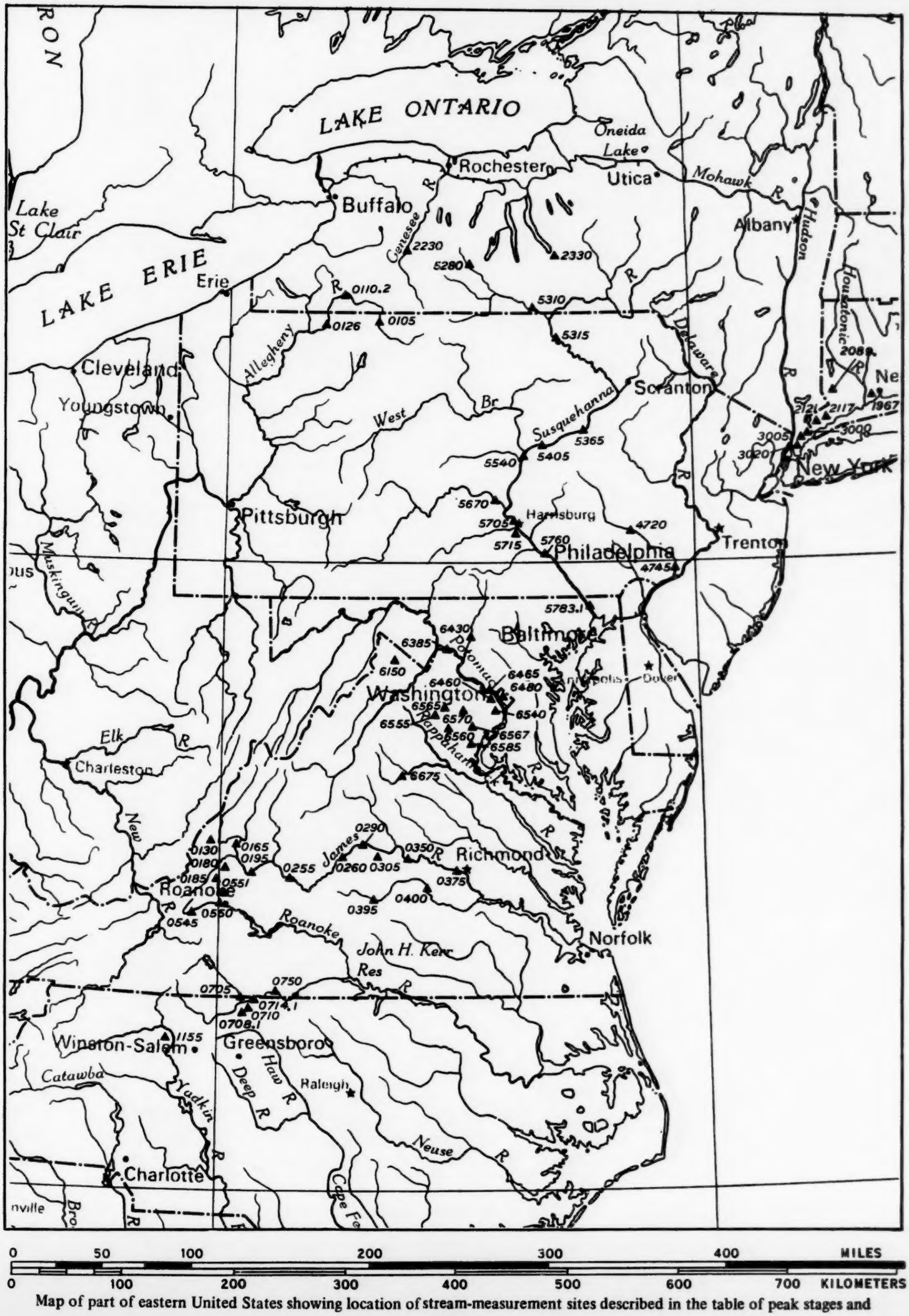


June	Cfs	June	Cfs	June	Cfs	June	Cfs
15	6,240	19	7,820	23	292,100	27	46,500
16	6,320	20	7,760	24	356,600	28	36,200
17	6,370	21	7,890	25	218,500	29	28,900
18	6,860	22	119,700	26	81,700	30	22,800

The combined effects of June flood-flows in the Susquehanna, Potomac, and James River basins and some smaller adjacent basins, resulted in the highest monthly flows into Chesapeake Bay for any month in at least the past 21 years. The combined monthly discharges in June totaled about 325,000 cfs (exceeding the previous high of May 1958), of which 186,000 cfs was contributed by the Susquehanna River basin. The inflow to the Bay from all the basins on June 24, was estimated to be 2,200,000 cfs.

STAGES AND DISCHARGES FOR THE FLOODS OF JUNE 1972 AT SELECTED SITES IN CONNECTICUT, NEW YORK, PENNSYLVANIA, MARYLAND-DISTRICT OF COLUMBIA, VIRGINIA, AND NORTH CAROLINA

Stream and place of determination	Drainage area (square miles)	Period of known floods	Maximum flood previously known			Maximum during present flood				
			Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge: Cfs	Discharge: Cfs per square mile	Recurrence interval (years)
CONNECTICUT										
WEPAWAUG RIVER BASIN										
1–1967 Wepawaug River at Milford	18.0	1962–72	Apr. 2, 1970	5.89	970	June 19	6.56	1,300	72	50
SASCO BROOK BASIN										
1–2089.5 Sasco Brook near Southport	7.28	1961–72	Dec. 4, 1968	4.15	340	19	7.00	1,000	137	50
BYRAM RIVER BASIN										
1–2117 East Branch Byram River at Round Hill	1.67	1960–72	Mar. 12, 1962	2.86	200	19	2.45	245	147	50
1–2121 East Branch Byram River at Riversville	11.2	1963–72	May 29, 1968	6.73	1,030	19	7.62	1,700	152	50
NEW YORK										
BLIND BROOK BASIN										
1–3000 Blind Brook at Rye	9.20	1944–72	Oct. 16, 1955	9.62	1,360	19	10.97	1,560	169	....
BEAVER SWAMP BROOK BASIN										
1–3005 Beaver Swamp Brook at Mamaroneck	4.71	1944–72	Mar. 12, 1962	3.09	167	19	3.00	190	40	....
BRONX RIVER BASIN										
1–3020 Bronx River at Bronxville	26.5	1944–72	June 15, 1969	7.31	1,900	19	8.75	(a)	......	....
SUSQUEHANNA RIVER BASIN										
1–5280 Fivemile Creek near Kanona	66.8	1937–72	Mar. 7, 1956	4.59	2,680	22	(a)	[b]27,000	404	[c]7
1–5310 Chemung River at Chemung	2,506	1904–72	May 28, 1946	23.97	132,000	22	(a)	[b]300,000	120	[c]2.4
ALLEGHENY RIVER BASIN										
3–0110.2 Allegheny River at Salamanca	1,608	1904–72	Mar. 8, 1956	15.11	49,100	23	(a)	[b]72,000	45	[c]1.2
STREAMS TRIBUTARY TO LAKE ONTARIO										
4–2230 Genesee River at Portageville	981	1908–72	May 17, 1916	[d]12.81	44,400	23	(a)	[b]70,000	71	[c]1.5
4–2330 Cayuga Inlet near Ithaca	35.2	1937–72	Aug. 13, 1942	7.58	4,110	22	(a)	[b]5,000	142	[c]1.2
PENNSYLVANIA										
DELAWARE RIVER BASIN										
1–4720 Schuylkill River at Pottstown	1,147	1902,	Feb. 28, 1902	21.0	53,900					
		1927–72	May 23, 1942	20.15	50,800	22	30	110,000	96	[c]1.1
1–4745 Schuylkill River at Philadelphia	1,893	1869,	Oct. 4, 1869	17.0	135,000					
		1902,	Mar. 1, 1902	14.8	98,000					
		1931–72	Aug. 24, 1933	14.7	96,200	23	14.7	150,000	79	[b]100
SUSQUEHANNA RIVER BASIN										
1–5315 Susquehanna River at Towanda	7,797	1865,	Mar. 17, 1865	25.0	[b]188,000					
		1913–72	May 29, 1946	25.08	191,000	23	31	300,000	38	[c]1.5
1–5365 Susquehanna River at Wilkes-Barre	9,960	1865,	Mar. 18, 1865	33.1	232,000					
		1899–72	Mar. 20, 1936	33.07	232,000	23	40.6	370,000	37	[c]1.3
1–5405 Susquehanna River at Danville	11,220	1899–72	Mar. 20, 1936	27.4	250,000	23	32.22	(a)	......	....
1–5540 Susquehanna River at Sunbury	18,300	1936–72	Mar. 19, 1936	34.65	556,000	23	35.9	800,000	44	[c]1.7
1–5670 Juniata River at Newport	3,354	1889,	June 1, 1889	35.9	209,000					
		1899–72	Mar. 19, 1936	34.24	190,000	23	33.97	170,000	51	[c]1.1
1–5705 Susquehanna River at Harrisburg	24,100	1890–72	Mar. 19, 1936	29.23	740,000	24	32.57	1,000,000	41	[c]1.5
1–5715 Yellow Breeches Creek near Camp Hill	216	1909–19	Aug. 22, 1915	8.61	5,550					
		1954–72				22	18	14,000	65	100
1–5760 Susquehanna River at Marietta	25,990	1931–72	Mar. 19, 1936	60.73	787,000	24	(a)	1,100,000	42	[c]1.6
ALLEGHENY RIVER BASIN										
3–0105 Allegheny River at Eldred	550	1939–72	July 19, 1942	27.6	55,000	23	29.05	65,000	118	[c]1.9
3–0126 Allegheny River at Warren	2,223	1936–72	Mar. 8, 1956	[d]19.95	60,500	23	9.45	[e]67,500	......	....
MARYLAND-DISTRICT OF COLUMBIA										
SUSQUEHANNA RIVER BASIN										
1–5783.1 Susquehanna River at Conowingo, Md	27,100	1967–72				24	....	1,100,000	41	[c]1.5
POTOMAC RIVER BASIN										
1–6385 Potomac River at Point of Rocks, Md	9,651	1889,	June 2, 1889	40.2	460,000					
		1895–72	Mar. 19, 1936	41.03	480,000	23	37.43	340,000	35	[f].9
1–6430 Monocacy River at Jug Bridge near Frederick, Md.	817	1889,	June 1889	30	56,000					
		1929–72	Aug. 24, 1933	28.1	51,000	23	34.7	81,000	99	[f]1.5
1–6465 Potomac River near Washington, D.C.	11,560	1889,	June 2, 1889	......	484,000					
		1930–72	Mar. 19, 1936	[d]28.1	484,000	24	21.98	[b]380,000	35	[f]1
1–6480 Rock Creek at Sherrill Drive, Wash., D.C.	62.2	1929–72	July 21, 1956	13.19	7,220	22	16.0	[b]15,000	241	[f]1.7
VIRGINIA										
POTOMAC RIVER BASIN										
1–6150 Opequon Creek near Berryville	57.4	1942	Oct. 1942	18.4	(a)					
		1943–72	Dec. 4, 1950	10.03	3,710	22	12.92	[b]6,700	117	[c]1.8
1–6460 Difficult Run near Great Falls	57.9	1935–72	Aug. 25, 1967	13.18	6,610	22	21.40	(a)	....	....
1–6540 Accotink Creek near Annandale	23.5	1947–72	July 22, 1969	11.85	7,870	22	[b]16	(a)	....	....
1–6555 Cedar Run near Warrenton	12.3	1942,	Oct. 1942	[b]13	....					
		1950–72	June 8, 1955	9.59	3,100	21	12.80	[b]10,000	813	[c]1.8
1–6560 Cedar Run near Catlett	93.4	1942,	Oct. 1942	[b]22	....					
		1950–72	June 8, 1955	17.25	7,300	21	27.3	(a)	......	....
1–6565 Broad Run at Buckland	50.5	1950–72	July 20, 1956	13.08	11,600	22	13.99	[b]14,000	277	[c]1.1
1–6567 Occoquan River near Manassas	343	1967,	Aug. 25, 1967	[b]16	....					
		1968–72	Feb. 10, 1970	12.32	9,650	22	50.3	(a)	......	....
1–6570 Bull Run near Manassas	148	1951–72	Aug. 25, 1967	19.27	13,000	22	36.80	(a)	....	....



Map of part of eastern United States showing location of stream-measurement sites described in the table of peak stages and discharges.

STAGES AND DISCHARGES FOR THE FLOODS OF JUNE 1972 AT SELECTED SITES IN CONNECTICUT, NEW YORK, PENNSYLVANIA, MARYLAND-DISTRICT OF COLUMBIA, VIRGINIA, AND NORTH CAROLINA—Continued

Stream and place of determination	Drainage area (square miles)	Period of known floods	Maximum flood previously known			Maximum during present flood				
			Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge		Recurrence interval (years)
								Cfs	Cfs per square mile	
VIRGINIA—Continued										
POTOMAC RIVER BASIN—Continued										
1–6585 South Fork Quantico Creek near Independent Hill.	7.64	1951–72	Aug. 3, 1969	8.40	1,040	June 21	11.36	[b]4,800	628	100
RAPPAHANNOCK RIVER BASIN										
1–6675 Rapidan River near Culpeper	472	1931–72	Oct. 16, 1942	30.3	58,100	22	29.53	55,600	118	100
JAMES RIVER BASIN										
2–0130 Dunlap Creek near Covington	164	1913,	Mar. 1913	18	....					
		1929–72	Aug. 20, 1969	13.13	10,300	21	15.65	[b]13,500	82.3	[c]1.2
2–0165 James River at Lick Run	1,373	1877,	Nov. 1877	[b]33	[b]120,000					
		1925–72	Mar. 18, 1936	25.65	66,600	21	27.01	[b]80,000	58.3	100
2–0180 Craig Creek at Parr	329	1925–72	Jan. 23, 1935	17.0	19,100	21	19.17	[b]22,000	66.8	[c]1.2
2–0185 Catawba Creek near Catawba	34.3	1940	Aug. 1940	13.26	....					
		1943–72	Mar. 1, 1954	6.58	5,670	21	10.38	[b]13,000	379	[c]1.8
2–0195 James River at Buchanan	2,075	1877,	Nov. 1877	34.9	[b]125,000					
		1898–72	Mar. 27, 1913	31.0	105,000	22	30.49	[b]100,000	48.1	[c]1.1
2–0255 James River at Holcombs Rock	3,259	1913	Mar. 1913	31.3	118,000					
		1927–72	Aug. 20, 1969	35.50	150,000	22	34.10	[b]140,000	43.0	[c]1.2
2–0260 James River at Bent Creek	3,683	1925–72	Aug. 20, 1969	24.77	144,000	22	27.13	[b]160,000	43.4	[c]1.5
2–0290 James River at Scottsville	4,584	1870,	Oct. 1870	30.7	(a)					
		1877	Nov. 1877	27.9	[b]160,000					
		1913	Mar. 1913	25.16	121,000					
		1925–72	Aug. 20, 1969	30.00	188,000	22	34.02	[b]280,000	61.1	[c]1.8
2–0305 Slate River near Arvonia	226	1926–72	Sept. 6, 1935	22.18	13,600	22	25.10	[b]16,900	73.8	[c]1.2
2–0350 James River at Cartersville	6,257	1877,	Nov. 1877,	30.4	(a)					
		1899–72	Aug. 21, 1969	33.75	250,000	22	37.87	[b]380,000	60.8	[c]2.0
2–0375 James River near Richmond	6,758	1935–72	Aug. 21, 1969	24.95	222,000	23	28.62	320,000	47.4	[c]1.7
2–0395 Appomattox River at Farmville	303	1926–72	Aug. 15, 1940	23.60	21,000	22	30.04	[b]40,000	132	[c]1.6
2–0400 Appomattox River at Mattoax	726	1900–05	Aug. 18, 1940	35.3	35,000	25	34.08	[b]31,000	42.7	[c]1.1
		1926–72								
ROANOKE RIVER BASIN										
2–0545 Roanoke River at Lafayette	257	1940,	Aug. 1940	12.2	(a)					
		1943–72	Sept. 30, 1959	11.56	15,600	21	[b]15.5	(a)	....	....
2–0550 Roanoke River at Roanoke	395	1899–72	Aug. 14, 1940	18.25	26,400	21	[b]19.6	[b]27,000	68.3	[c]1.1
2–0551 Tinker Creek near Daleville	11.7	1940,	Aug. 1940	9.0	(a)					
		1956–72	Aug. 25, 1961	8.52	2,180	21	9.82	[b]3,200	274	(a)
2–0750 Dan River at Danville	2,050	1934–72	Aug. 15, 1940	20.96	75,000	22	21.38	[b]69,000	33.6	[b]100
NORTH CAROLINA										
ROANOKE RIVER BASIN										
2–0705 Mayo River near Price	260	1929–72	Oct. 19, 1937	14.00	30,000	21	14.03	30,000	115	[f]1.2
2–0708.1 Jacobs Creek near Wentworth	16	1954–72	Oct. 15, 1954	28.94	5,290	21	30.2	4,300	269	[f]1.3
2–0710 Dan River near Wentworth	1,050	1908,	1908	34.9	....					
		1939–72	Sept. 18, 1945	27.78	56,800	22	31.6	74,000	70	[f]1.1
2–0714.1 Matrimony Creek near Leaksville	12.0	1958–72	....	....	....	21	18.88	2,430	202	[f]1.5
PEE DEE RIVER BASIN										
2–1155 Forbush Creek near Yadkinville	21.7	1940–72	Aug. 10, 1970	12.37	2,840	21	15.12	4,450	205	[f]1.0

[a]Not determined.
[b]About.
[c]Approximate ratio of discharge to that of 100-year flood.
[d]Site and datum then in use.
[e]Flow regulated by lakes and reservoirs.
[f]Approximate ratio of discharge to that of 50-year flood.

NORTHEAST

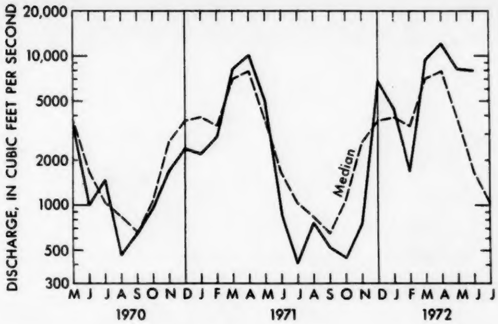
[Atlantic Provinces and Quebec; Delaware, Maryland, New York, New Jersey, Pennsylvania, and the New England States]

RECORD-BREAKING FLOODS JUNE 22–24 CAUSED BY TROPICAL STORM AGNES BROUGHT DEATH AND DESTRUCTION TO LARGE PARTS OF PENNSYLVANIA, NEW YORK, AND MARYLAND, AND LESS SEVERE DAMAGES TO DELAWARE, NEW JERSEY, AND CONNECTICUT. STREAMFLOW REMAINED IN THE ABOVE-NORMAL RANGE IN NEARLY THE ENTIRE REGION, BUT DECREASED SEASONALLY IN MOST OF NEW ENGLAND AND IN QUEBEC AND THE MARITIME PROVINCES.

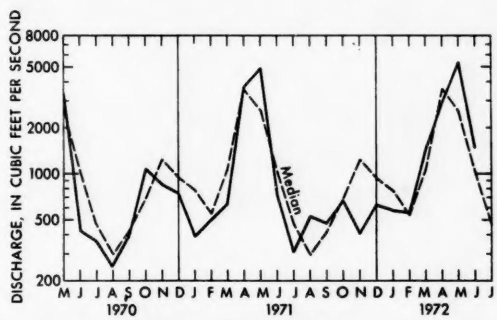
Heavy rains that shortly preceded tropical storm Agnes in southeastern New York (mainly Westchester County) and southwestern Connecticut caused unusually high flows on many small streams on June 19. Data on peak stages and discharges at 7 sites are listed in the table on page 4. Major events and statistics associated with floods caused by tropical storm Agnes are described on the preceding pages.

The extremely high daily discharges occurring during the floods caused the monthly mean flows of affected streams to remain high during June (see graph of Susquehanna River at Conklin, N.Y.), instead of decreasing sharply as is normal for the month and as occurred outside of the areas affected by the flood-producing storms (see graph of Pemigewasset River at Plymouth, N.H.).

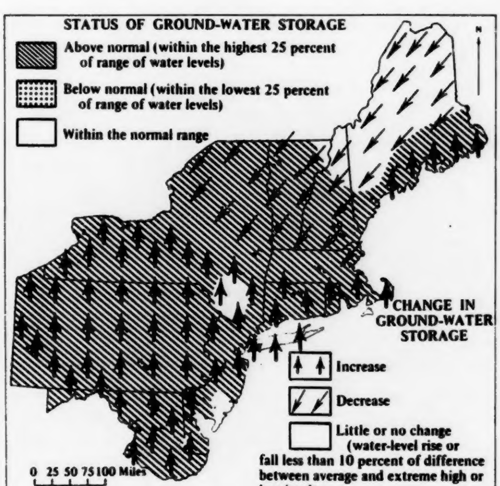
Ground-water levels in water-table wells rose to highest end-of-June levels in more than 25 years of record in nearly the entire region, other than Long Island, N.Y., and northern New England (see map), as a result of recharge from unusually heavy, flood-producing rains, mainly associated with tropical storm Agnes. (June is normally a month of declining levels.) Other factors contributing to high water levels included relatively high carryover from end of May and below-average temperatures during June, with correspondingly decreased rates of evapotranspiration. Water levels in some wells in Pennsylvania, Connecticut, Rhode Island, and southeastern Massachusetts equalled or exceeded the highest levels recorded in *any* month during the past 25 years. Levels were in or above the normal range throughout the States in the region.



Monthly mean discharge of Susquehanna River at Conklin, N.Y. (Drainage area, 2,232 square miles.)



Monthly mean discharge of Pemigewasset River at Plymouth, N.H. (Drainage area, 622 square miles.)



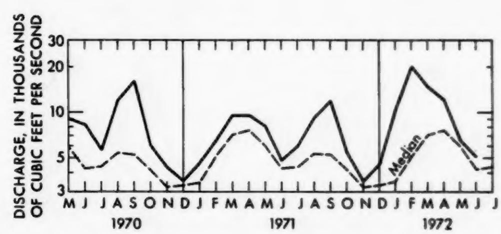
Map above shows ground-water storage near end of June and change in ground-water storage from end of May to end of June.

SOUTHEAST

[Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia]

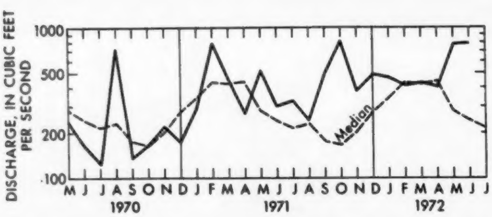
FLOWS INCREASED AND REMAINED IN THE ABOVE-NORMAL RANGE IN PARTS OF NORTH CAROLINA, VIRGINIA, AND WEST VIRGINIA, WITH SOME SEVERE FLOODING CAUSED BY RAINS OF TROPICAL STORM AGNES. ELSEWHERE IN THE REGION, FLOWS DECREASED SEASONALLY. FLOWS WERE IN THE BELOW-NORMAL RANGE IN MUCH OF ALABAMA AND SOUTHERN MISSISSIPPI.

The storm Agnes that moved across Florida's Panhandle on the 19th as a hurricane, dumped upwards of 4 inches of rain on the Southeast—sometimes much more, as in mountain and Piedmont areas of North Carolina and Virginia—in its northward trek toward Pennsylvania and New York. In Florida, rains relieved relatively dry conditions and prevented streamflows from decreasing into the below-normal range. In the north-central part of the State, the monthly flow of Suwannee River at Branford decreased moderately (see graph) but at monthend the daily flow was estimated to be 8,000 cfs.



Monthly mean discharge of Suwannee River at Branford, Fla. (Drainage area, 7,090 square miles.)

Severe flooding in North Carolina was limited to mountain and northern Piedmont areas in the north-central and western parts of the State, with some rainfall totals of as much as 10 inches. Damage estimates reportedly totaled nearly 4 million dollars, nearly half of this being in Rockingham County. Record or near-record floods occurred on the Dan, Smith, Mayo, and Yadkin Rivers and many of their upper tributaries. Peak discharges on some streams in these basins exceeded those likely to occur on an average of only once in 50 years (see table on page 6 and map on page 5). Daily discharge on June 22 of South Yadkin River near Mocksville in central North Carolina (see graph) was 8,380 cfs, only 300 cfs less than the alltime highest daily flow (October 1964) in the 34 years of record. Lesser flooding occurred in the Catawba River basin and on portions of the Cane, South Toe, and Pigeon Rivers in the Tennessee River basin.



Monthly mean discharge of South Yadkin River near Mocksville, N.C. (Drainage area, 313 square miles.)

Flooding was especially severe in Virginia, beginning on the 21st, as a result of tropical storm Agnes; damages may be close to 300 million dollars. Highest flows of record at about 40 stream-gaging stations, and peak flows at some 25 stations may have equalled or exceeded those of the once-in-100-year flood. These stations were located primarily in (a) northern Virginia (Clarke, Loudoun, Fauquier, Fairfax, and Prince William Counties); (b) on the James River and some of its tributaries, notably the Appomattox River; (c) the upper Roanoke River; and (d) lower Dan River. On the upper Roanoke River and lower Dan River, peak discharges exceeded those of the 1940 flood. On the James River, the flood crest exceeded the peak of August 1969 at most gages. At Cartersville, 35 miles west-northwest of Richmond, the James River reached a peak of about 380,000 cfs on the 22d, highest in at least 95 years and half again as much as the previous record high on August 21, 1969. (See station 2-0350 on table on page 4).

Flows were in the above-normal range in most of West Virginia as the result of the rains of Agnes, but not nearly of the great magnitude of flows that occurred in the States to the east. Daily discharge of Potomac River at Paw Paw, West Virginia (drainage area, 3,109 square miles) reached its high for the month on the 23d—53,400 cfs—slightly more than half the daily discharge recorded during the flood of October 16, 1942 (104,000 cfs).

Flow of Silver Springs in north-central Florida decreased to 750 cfs, 98 percent of normal. In the southeastern part of the State, flow of Miami Canal at Miami increased by 118 cfs to 303 cfs, 81 percent of normal.

Ground-water levels generally rose east of the Appalachians in areas receiving recharge from heavy rains of tropical storm Agnes, and levels reached new highs in some areas. For example, in 4 observation wells in northern Virginia, levels became highest of record for end of June in all 4 wells, and were alltime high for end of any month in 3 of the 4 wells (41, 16, and 15 years of record, respectively). In North Carolina, levels near monthend continued above average. In Alabama, levels generally declined but continued near average near monthend. In Mississippi and Kentucky, levels also declined. Levels near monthend in shallow aquifers in central Kentucky were below average, but in deeper aquifers to the east and west were slightly above average.

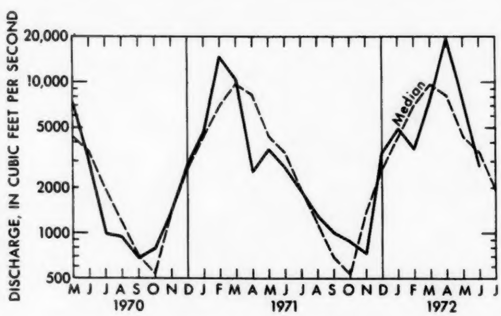
WESTERN GREAT LAKES REGION

[Ontario; Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin]

STREAMFLOW DECREASED SEASONALLY AND WAS IN THE NORMAL RANGE IN MOST OF THE REGION, BUT REMAINED IN THE ABOVE-NORMAL RANGE IN THE PARRY SOUND AREA (NORTH MAGNETAWAN RIVER) OF ONTARIO, EAST OF LAKE HURON. FLOWS WERE HIGH ALSO IN EASTERN OHIO, CAUSED MAINLY BY RAINS OF TROPICAL STORM AGNES. ON THE OTHER HAND FLOWS WERE APPROACHING OR MOVED SLIGHTLY INTO THE BELOW-NORMAL RANGE IN SOUTHERN MICHIGAN AND SOUTHWESTERN ILLINOIS.

In south-central Minnesota, locally damaging flash-flooding occurred June 7–8 on the Watonwan River (Minnesota River basin) in the Madelia area as a result of 5 to 8 inches of rain. Flows in the Minnesota River basin were high at the beginning of the month as a result of heavy rainfall the last of May. In Illinois, severe flooding hit the Chicago area at midmonth due to locally heavy thunderstorm rainfall. In Ohio, 4 inches of rain from tropical storm Agnes caused localized flooding June 23 in the Cleveland area. East of Cleveland, flooding near the mouth of the Chagrin River resulted from high winds driving water upriver from Lake Erie.

In most of the Western Great Lakes region, streamflow decreased, as is normal for June (see graph of East Fork White River at Shoals in southwestern Indiana).



Monthly mean discharge of East Fork White River at Shoals, Ind. (Drainage area, 4,927 square miles.)

Ground-water levels in water-table wells declined in most of the region but rose in northern areas of Indiana and Minnesota. Levels near monthend remained above average in Minnesota and Indiana, and were above average also in most of Michigan. Levels were near average in Ohio and Wisconsin. In deep artesian aquifers, levels continued to decline in the Minneapolis-St.Paul, Minn., area and in the Milwaukee, Wis., area.

MIDCONTINENT

[Manitoba and Saskatchewan; Arkansas, Iowa, Kansas, Louisiana, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas]

CATASTROPHIC FLOODING STRUCK THE RAPID CITY AREA OF SOUTHWESTERN SOUTH DAKOTA FOLLOWING TORRENTIAL RAINS IN THE BLACK HILLS ON JUNE 9 AND 10. ELSEWHERE IN THE MIDCONTINENT, STREAMFLOW DECREASED AND WAS IN OR BELOW THE NORMAL RANGE IN NEARLY THE ENTIRE REGION. THE LARGE AREA OF BELOW-NORMAL FLOWS WAS CENTERED ON MISSOURI, ARKANSAS, AND EASTERN OKLAHOMA.

The most disastrous flooding in the history of South Dakota occurred June 9th and 10th in the Rapid City, Sturgis, and Keystone areas of southwestern South Dakota, on the northern and eastern edges of the Black Hills. The cause was torrential rainfall of up to 7 inches or more, mostly within a 6-hour period—some reports indicated that the storm totals may have been as much or more than 10 inches in a few mountain areas, equal to roughly half the total precipitation that normally falls in an entire year. The tragic effect was a sudden flood that took more than 200 lives and caused more than 100 million dollars in damage.

The storm and many of its worst effects were telescoped into a relatively short period of time. The deluge of rainfall occurred principally during the late afternoon and evening hours of June 9. Within a few hours after midnight, most of the lives had been snuffed out and most of the destruction had taken place. The flood deaths and damages were caused mainly by three rampaging streams—Rapid Creek that flows through Rapid City; Battle Creek that flows through Keystone, south of Rapid City; and Bear Butte Creek that flows through Sturgis, northwest of Rapid City. Rapid Creek is the largest of the three streams, and Rapid City was the main populated area that suffered the full fury of the flood. According to the June 26, 1972, issue of the *Rapid City Journal:*

> "A Red Cross survey indicates that some 500 mobile homes and 700 dwellings were destroyed. Sustaining damage were 800 mobile homes, 1,700 dwellings, and 60 farm buildings. Business firms destroyed numbered 150; motor vehicles destroyed or damaged have been estimated at 5,000."

The map on page 10 shows the streams in the Rapid City-Keystone-Sturgis area. Peak stages and discharges at the 20 sites indicated on the map are listed on page 11.

Preliminary estimates indicate that a flood of the magnitude of that which occurred at Rapid City is likely to occur on the average only once in more than 200 years—perhaps even in a considerably longer period of time. The peak discharge of Rapid Creek above Canyon Lake, near Rapid City (item 12 on the map and table), on June 9, was 31,200 cfs. The highest previous discharge at that site during 26 years of record (July 1946 to date) was only 2,600 cfs, May 23, 1952. Principal known floods in the immediate vicinity of Rapid City include those on the dates listed below; it is believed that none of the floods on those dates were of as great a magnitude as that of June 9–10, 1972:

July 26, 1905
May 12, 1920
May 24, 1933
June 21–24, 1947
May 22–24, 1952
July 13–15, 1962

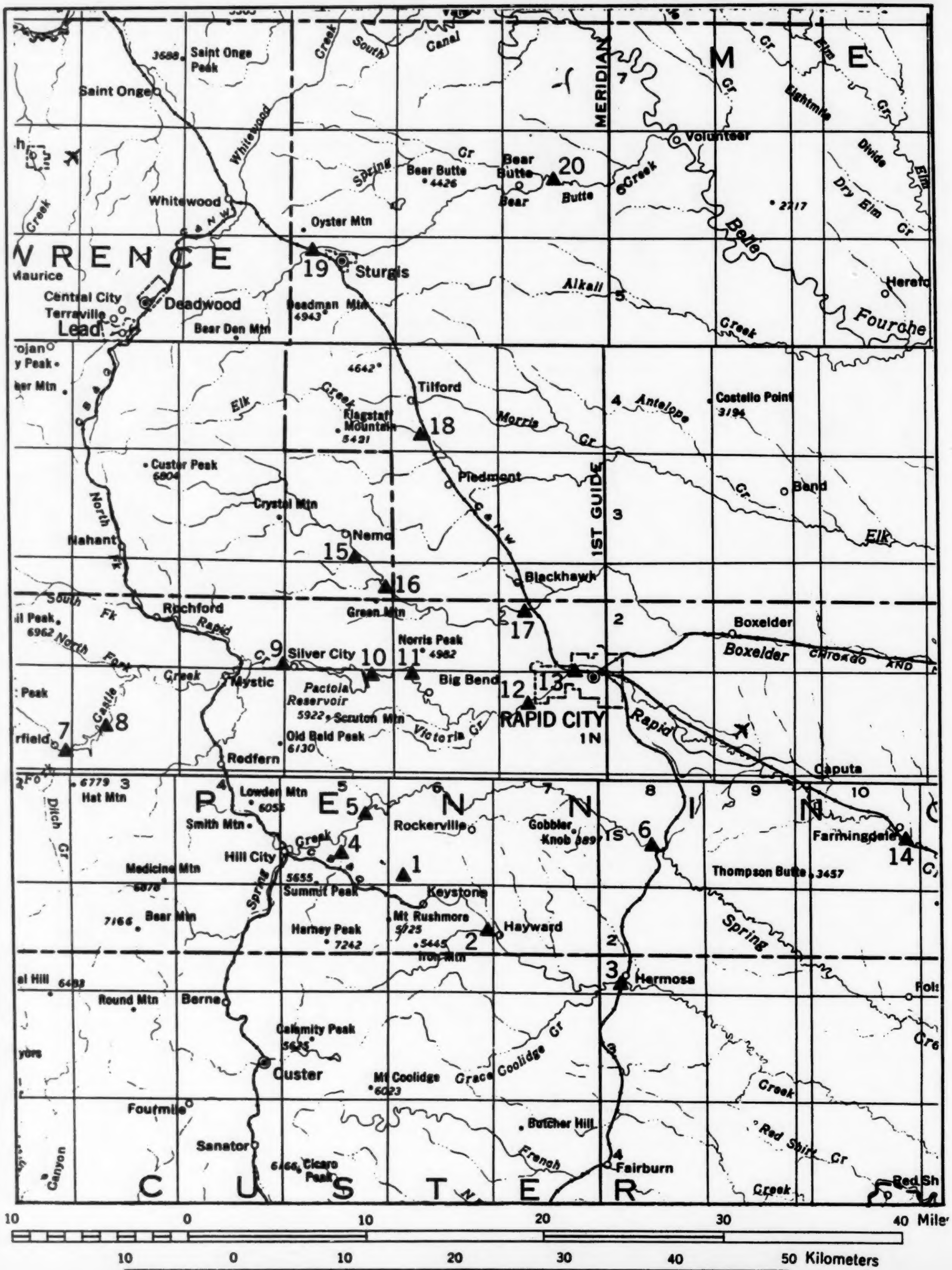
Two reservoirs stored runoff during most of the flood of June 1972. Deerfield Reservoir, on Castle Creek, (between sites 7 and 8 on map) received water from an area of about 95 square miles; the reservoir first received storage December 4, 1945 and had maximum observed contents (prior to 1972) of 15,340 acre-feet on May 22, 1952. Provisional data for the June 1972 flood period show contents of 15,376 acre-feet at midnight, June 9, and 15,388 acre-feet at midnight, June 10.

Pactola Reservoir, on Rapid Creek (between sites 9 and 10 on map) receives water from 319 square miles; the reservoir first received storage water August 22, 1956, and had maximum observed contents (prior to 1972) of 60,970 acre-feet on May 19, 1965. Provisional data for the June 1972 flood period show contents of 55,570 acre-feet at midnight, June 8, 56,224 acre-feet at midnight, June 9, and 57,091 acre-feet at midnight, June 10.

Canyon Lake, on Rapid Creek at the southwest boundary of the city (just downstream from site 8 on the map) was a relatively shallow lake, formed by a 500-foot long earth-and-rock dam, with a concrete spillway, and was used primarily for recreation. By about 11 p.m., June 9, the floodwaters from the 52-square-mile drainage area downstream from Pactola Dam, had overtopped and breached this dam, thus adding to the water and woes of those in the floodpath downstream from the lake.

In other parts of the Midcontinent region, thunderstorm rainfall caused local flooding in widely scattered areas, including Marshalltown, Iowa (Iowa River basin), the Republican River basin in Nebraska, in Houston and Austin, Texas, and in parts of North Dakota. The monthly flows of most streams in flood-free areas were less than those in May but remained far above median in places where May flows had been unusually high (see graph of Cannonball River at Breien in south-central North Dakota).

In contrast to the high flows described in previous paragraphs, streamflow in some southern parts of the region was far *below* normal. For example, in southeast Arkansas, monthly mean discharge of Saline River near Rye (drainage area, 2,062 square miles), was 83.7 cfs, 12 percent of the June median and lowest flow for June in the 35 years of record. Also, in southeastern Oklahoma,



Map of part of southwestern South Dakota, including Rapid City, showing location of stream-measurement sites described in the table of peak stages and discharges.

STAGES AND DISCHARGES FOR THE FLOODS OF JUNE 1972 AT SELECTED SITES IN SOUTH DAKOTA

Number on map	Stream and place of determination	Drainage area (square miles)	Period of known floods	Maximum flood previously known			Maximum during present flood				
				Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge		Recurrence interval (years)
									Cfs	Cfs per square mile	
	SOUTH DAKOTA										
	CHEYENNE RIVER BASIN										
1	6–4038 Battle Creek tributary near Keystone.	0.88	1956–72	June 23, 1967	5.41	16	June 9	-------	1,330	1,500	-------
2	6–4040 Battle Creek near Keystone.	66	1945–47 1962–72	May 24, 1965	3.71	718	9	-------	26,200	396	[a]7
3	6–4060 Battle Creek at Hermosa.	178	1950–72	May 22, 1952	14.00	2,950	9	-------	44,100	248	[a]7
4	6–4069 Palmer Creek near Hill City.	8.24	1956–72	June 16, 1962	7.55	-------	9	17.06	4,400	534	-------
5	--------- Spring Creek at old Highway 40, near Sheridan.	[b]110	----------	--------------	------	-------	9	-------	14,800	[b]135	-------
6	6–4085 Spring Creek near Hermosa.	199	1950–72	June 7, 1967	5.49	772	9	-------	13,400	67	-------
7	6–4090 Castle Creek above Deerfield Reservoir near Hill City.	83	1949–72	May 22, 1952	5.81	1,120	10	2.14	19	.23	<2
8	6–4100 Castle Creek below Deerfield Dam.	96	1946–72	May 22, 1952	------	[c]200	10	1.16	26	0.27	-------
9	6–4105 Rapid Creek above Pactola Reservoir at Silver City.	292	1954–72	May 15, 1965	10.44	2,060	10	5.74	228	.78	-------
10	6–4115 Rapid Creek below Pactola Dam.	320	1929–42, 1947–72	May 22, 1952	[d]6.74	2,170	9	8.62	[e]378	----------	-------
11	--------- Rapid Creek at Highway 40, 10 miles west of Rapid City.	----------	----------	--------------	------	------	9	-------	[f]5,750	----------	-------
12	6–4125 Rapid Creek above Canyon Lake, near Rapid City.	[g]371	1947–72	May 23, 1952	8.08	2,600	9	-------	[f]31,200	[h]600	-------
13	6–4140 Rapid Creek at Rapid City.	[g]410	1905–06, 1920; 1942–72	May 12, 13, 1920 July 13, 1962	13.6 8.37	------ 3,300	9	-------	[f]50,600	[h]556	-------
14	6–4215 Rapid Creek near Farmingdale.	[g]602	1947–72	June 21, 1947	8.4	2,640	9	11.9	[f]7,420	[h]26	[a]1.2
15	6–4224 Estes Creek near Nemo.	[b]6	----------				9	-------	5,550	925	-------
16	6–4225 Boxelder Creek near Nemo.	96	1911, 1945–47, 1966–72	1911 May 2, 1946	14 5.75	------ 1,180	9	-------	29,000	302	[a]4
17	--------- Boxelder Creek at Highway 79 near Blackhawk.	----------	----------	--------------	------	-------	9	-------	51,800	----------	-------
18	--------- Elk Creek at railroad bridge 2.5 miles northwest of Piedmont.	----------	----------	--------------	------	-------	9	-------	11,600	----------	-------
19	6–4373 Bear Butte Creek at railroad bridge, 1.5 mile northwest of Sturgis.	----------	----------	--------------	------	-------	10	-------	19,500	----------	-------
20	6–4375 Bear Butte Creek near Sturgis.	192	1883, 1909, 1946–72	[i]June 16, 1962	12.63	12,700	10	11.53	6,370	33	[a]0.6

[a] Ratio of discharge to that of 100-year flood.

[b] About.

[c] Daily mean.

[d] Site and datum then in use.

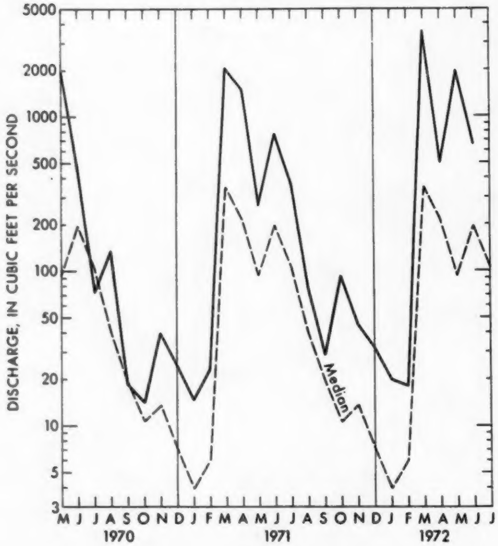
[e] Outflow from reservoir prior to closing of gates near beginning of storm.

[f] Pactola Dam gates were closed near beginning of storm; peak discharge includes little, if any, flow from reservoir.

[g] Includes 319 square miles of noncontributing area; Pactola Dam gates were closed near beginning of storm.

[h] Computed on basis of contributing area only.

[i] Not as great as floods of 1883 and 1909.



Monthly mean discharge of Cannonball River at Breien, N. Dak. (Drainage area, 4,100 square miles.)

monthly mean discharge of Washita River near Durwood (drainage area, 7,202 square miles), was 266 cfs, 16 percent of median and second lowest monthly flow for June in the 44 years of record.

In Manitoba, the level of Lake Winnipeg at Gimli, averaged 716.25 feet above mean sea level, 2.45 feet above the long-term mean for June, and 0.93 below the 59-year maximum monthly mean (in 1966).

Ground-water levels declined in most of the region but rose in western Kansas (except in heavily pumped areas). Monthend levels were near average in North Dakota and Nebraska; slightly below average in western Iowa; and above average in eastern Iowa. In the rice-irrigation area of east-central Arkansas, monthend water level in the shallow aquifer (Quaternary deposits) was unchanged and was in the same range of values that the June level has been since 1965. In central Louisiana, levels in the observation well tapping the terrace aquifer changed only slightly. In northern Louisiana, levels in the Sparta Sand continued to decline. In Texas, levels rose at Austin, but declined at El Paso, Houston, and San Antonio. Monthend levels were above average in the Edwards Limestone at Austin and San Antonio; below average in the bolson deposits at El Paso, and alltime lowest in 30 years of record in the Evangeline aquifer at Houston.

WEST

[Alberta, and British Columbia; Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming]

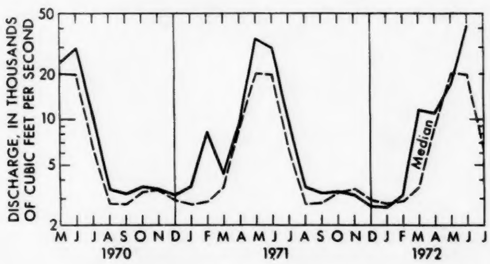
STREAMFLOW GENERALLY INCREASED IN MOST OF THE STATES AND PROVINCES OF THE REGION BUT DECREASED IN WASHINGTON, CALIFORNIA, AND VANCOUVER ISLAND, AND IN PARTS OF ALBERTA PROVINCE, OREGON, AND NEW MEXICO. MONTHLY MEAN DISCHARGES WERE IN THE ABOVE-NORMAL RANGE IN A LARGE AREA CENTERED ON NORTHERN IDAHO AND WERE BELOW THE NORMAL RANGE OVER MUCH OF CALIFORNIA AND NEW MEXICO AND IN SOUTHWESTERN UTAH AND SOUTHERN COLORADO. FLOODING OCCURRED IN SEVEN OF THE THIRTEEN STATES AND PROVINCES OF THE REGION.

Warm temperatures, combined with an above-normal snowpack, resulted in extreme flooding, considered the worst since 1894, in Okanogan River basin, in north-central Washington, May 30 to June 3. In the 70-mile reach between Oroville and Brewster many square miles of floodplain were inundated and flood waters reached depths of 6 feet in the downtown area of Okanogan. Peak discharge of Similkameen River, the principal tributary of Okanogan River, was 46,500 cfs (greatest in 61 years of record) on June 1 at the gaging station near Nighthawk (drainage area, 3,550 square miles), about 12 miles upstream from the confluence of the two streams at Oroville. Some 20 miles downstream from Oroville, peak discharge of Okanogan River near Tonasket (drainage area, 7,280 square miles) on June 2, was 45,200 cfs, greatest in 43 years of record. Extreme flooding occurred also in Methow River basin, adjacent to Okanogan River basin on the west. Monthly mean discharge of Skyomish River near Goldbar in the mountains of northern Washington, remained only slightly less than the highest monthly mean discharge for any month in the 44 years of record.

In Alberta, major flooding, resulting from excessive rainfall during three weekend storms, June 10–11, 17–18, and 24–25, occurred on several streams. Total rainfall of 10.03 inches was observed at Rocky Mountain House, in North Saskatchewan River basin about 100 air miles southwest of Edmonton. Flooding occurred in this basin and monthly mean discharge of North Saskatchewan River at Edmonton, in south-central Alberta, increased into the above-normal range and was within 10 percent of the highest June flow in 61 years of record. About 180 air miles southwest of Edmonton, monthly mean discharge of Bow River at Banff, 7,310 cfs (drainage area, 858 square miles), was highest for June in 62 years of record; flow on the maximum day was 10,900 cfs on the 12th.

In southern British Columbia, monthly mean discharge of Fraser River at Hope, 382,000 cfs (drainage area, 78,300 square miles), was highest for June in record that began in 1912, and in the above-normal range for the fourth consecutive month. In west-central British Columbia, on Skeena River at Usk, the maximum daily mean, 275,000 cfs, June 12(drainage area, 15,000 square miles), was the highest in 39 years of record.

In western parts of Montana and Idaho, rapid melting of an extremely heavy snowpack caused record-breaking flood stages and discharges early in June. Below-normal temperatures during most of May had delayed seasonal snowmelt in those basins. Flood peaks along Bitterroot River, and all of its tributaries, draining western slopes of the Continental Divide in western Montana, were highest of record. Recurrence intervals of the peak discharges generally were greater than 50 years. Highest peak stage and discharge of record occurred also on Trail Creek near Wisdom, Montana, draining eastern slopes of the Divide, adjacent to headwaters of Bitterroot River. Clark Fork near Plains, Montana (drainage area, 19,958 square miles), crested at about 100,000 cfs, second highest peak discharge in 62 years of record; and upstream at St. Regis, melting of the unusually heavy snowpack resulted in the highest monthly (see graph)



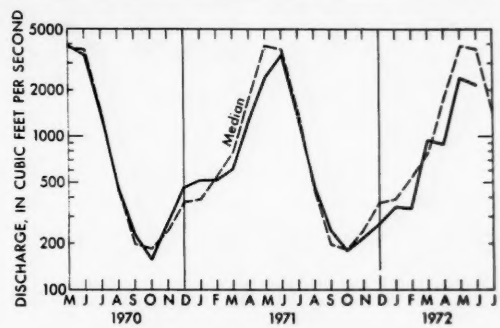
Monthly mean discharge of Clark Fork at St. Regis, Mont. (Drainage area, 10,709 square miles.)

and daily discharges—43,830 cfs and 68,000 cfs (on several days), respectively, in 56 years of daily discharge record. In western Idaho, crest stages and discharges on the lower Salmon and Clearwater Rivers, and the Snake River below the Salmon River, were near the 1948 stages and discharges, which are the highest of record in those basins. The Salmon River at White Bird (drainage area, 13,550 square miles), had a daily discharge of 98,500 cfs on the 2d, highest for June in the 60 years of record.

In western Wyoming, peak discharges on many streams in the Green River basin upstream from Fontanelle Reservoir, and in the Wind-Bighorn River basin, were near, or above, the highest of record. Local flooding at scattered spots in the State was caused by intense thunderstorms.

In the Sacramento-San Joaquin delta area of California, Andrus and Brannan Islands (below sea level in a tidal area) were flooded on June 21 by a sudden rupture of 150 feet of a levee under repair which was holding out the San Joaquin River. Upland runoff was low; tides and wind were moderately high. A hastily erected dirt fill protecting the town of Isleton, also failed, flooding that community of 2,000 persons. All residents and vacationers were evacuated from the islands and there was no known loss of life. Total loss is estimated at $41 million. Flash flooding occurred June 7 in Bakersfield, in the southern San Joaquin Valley, causing one death and damage estimated at $175,000. Streamflow generally was below the normal range in the State. Cumulative runoff of the Sacramento and San Joaquin Rivers to the San Francisco Bay-delta area, from October 1971 through May 1972, was the lowest for this 8-month period since 1961.

Flow of Kings River above North Fork, tributary to San Joaquin River, decreased to 59 percent of the median for June (see graph) and remained in the below-normal range for the 3d consecutive month.



Monthly mean discharge of Kings River above North Fork, Calif. (Drainage area, 952 square miles.)

In Arizona, streamflow increased throughout the State and was above the normal range on Verde River below Tangle Creek, above Horseshoe Dam, after being in the below-normal range during February, March, and April. Widespread flooding occurred in residential sections of Scottsdale and Phoenix, June 22, when as much as 4 inches of rain fell in areas north and east of Phoenix. On Little Colorado River near Cameron, the first flow occurred since February 26. Storage decreased in most reservoirs. Combined contents of Lakes Mead and Mohave and contents of the Salt-Verde reservoirs system were 93 and 92 percent of average, respectively, at monthend.

In New Mexico, streamflow remained in the below-normal range except in the Gila River basin, where flow was in the normal range for June. Thunderstorms occurred over most of the State and some precipitation stations received more than double the normal June rainfall. Flooding occurred in the Carlsbad and Roswell areas, June 12 and 19, respectively, caused by locally severe thunderstorms. Reservoir storage continued to be far below normal.

Streamflow in Utah was above the normal range in parts of the north but remained in the below-normal range in the south. Monthly mean discharge of Beaver River near Beaver (drainage area, 82 square miles), in southwestern Utah, was 28.6 cfs, second lowest for June in 58 years of record. Storage in Bear Lake, on the

Utah-Idaho border, northeast of Salt Lake City, reached its peak for the year on June 29, at the third highest content in 54 years of record. The elevation of Great Salt Lake declined 0.35 foot during the month (to 4,199.25 feet above mean sea level), 1.10 feet higher than a year ago.

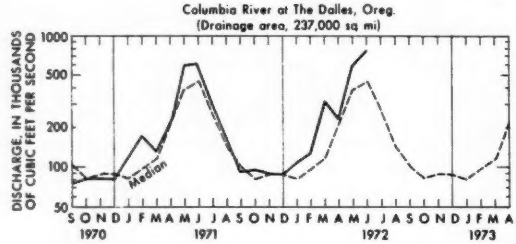
Ground-water levels generally rose in northern parts of the West, including Idaho, Montana, northeastern Utah, and eastern Washington. Levels declined in western Washington and southern California; and changed only slightly in southern New Mexico. Levels near monthend were above average in Montana, Washington, and northeastern and southeastern Utah. Levels remained near average in southern California and were generally below average in southern Arizona and New Mexico.

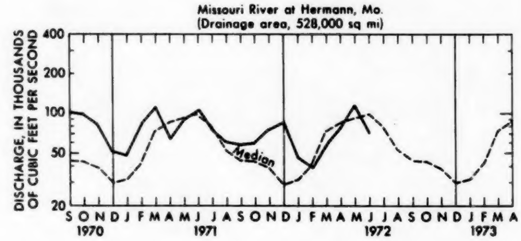
ALASKA

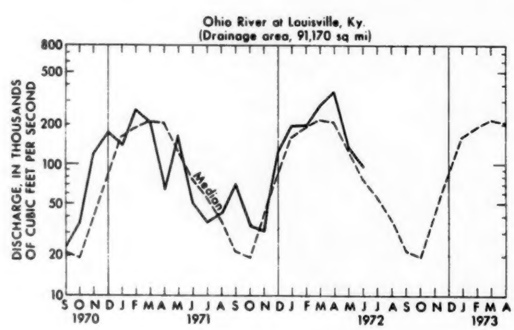
Streamflow increased seasonally in the south and decreased seasonally in the Chena River basin of central Alaska. Below-normal temperatures on Kenai Peninsula, just south of Anchorage, resulted in continued below-normal flow in Kenai River at Cooper Landing (drainage area, 634 square miles), where the June monthly mean discharge, 3,335 cfs, was the lowest for the month since records began in May 1947. Monthly flows at this station have been below the normal range in four of the nine months since October 1971, and cumulative runoff for the first 9 months of the water year (through June 30) was only 67 percent of the long-term median, 1948-70. Also, the cool, cloudy weather retarded snowmelt from the above-normal snowpack in the Cardova area, along the coast, 150 miles east of Anchorage. Elsewhere in the State, streamflow was in the normal range.

Ground-water levels rose in the Anchorage area. Levels near monthend in the Kenai Peninsula were the highest since 1970.

HYDROGRAPHS OF THREE MAJOR RIVERS







Provisional data; subject to revision

USABLE CONTENTS OF SELECTED RESERVOIRS NEAR END OF JUNE 1972

[Contents are expressed in percent of reservoir capacity. The usable storage capacity of each reservoir is shown in the column headed "Normal maximum."]

Reservoir — Principal uses: F–Flood control; I–Irrigation; M–Municipal; P–Power; R–Recreation; W–Industrial

Reservoir	End of May 1972	End of June 1972	End of June 1971	Average for end of June	Normal maximum
	Percent of normal maximum				
NORTHEAST REGION					
NOVA SCOTIA					
Rossignol, Mulgrave, Falls Lake, St. Margaret's Bay, Black, and Ponhook Reservoirs (P)	99	91	85	70	223,400 (a)
QUEBEC					
Gouin (P)	42	49	70	70	6,487,000 ac-ft
Allard (P)	91	89	86	82	280,600 ac-ft
MAINE					
Seven reservoir systems (MP)	97	98	86	86	179,300 mcf
NEW HAMPSHIRE					
Lake Winnipesaukee (PR)	107	104	97	94	7,200 mcf
Lake Francis (FPR)	88	96	90	87	4,326 mcf
First Connecticut Lake (P)	99	93	94	90	3,330 mcf
VERMONT					
Somerset (P)	94	95	86	86	2,500 mcf
Harriman (P)	78	83	77	83	5,060 mcf
MASSACHUSETTS					
Cobble Mountain and Borden Brook (MP)	95	95	88	88	3,394 mcf
NEW YORK					
Great Sacandaga Lake (FPR)	100	105	92	92	34,270 mcf
Indian Lake (FMP)	106	111	95	101	4,500 mcf
New York City reservoir system (MW)	100	100	92	....	547,500 mg
NEW JERSEY					
Wanaque (M)	100	101	93	88	27,730 mg
PENNSYLVANIA					
Wallenpaupack (P)	90	91	88	79	6,875 mcf
Pymatuning (FMR)	100	111	96	97	8,191 mcf
MARYLAND					
Baltimore municipal system (M)	100	102	99	91	85,340 mg
SOUTHEAST REGION					
NORTH CAROLINA					
Bridgewater (Lake James) (P)	98	99	81	89	12,580 mcf
High Rock Lake (P)	90	100	88	76	10,230 mcf
Narrows (Badin Lake) (P)	97	99	93	98	5,616 mcf
SOUTH CAROLINA					
Lake Murray (P)	96	98	94	77	70,300 mcf
Lakes Marion and Moultrie (P)	92	90	90	71	81,100 mcf
SOUTH CAROLINA--GEORGIA					
Clark Hill (FP)	77	77	74	73	75,360 mcf
GEORGIA					
Burton (PR)	99	100	87	90	104,000 ac-ft
Lake Sidney Lanier (FMPR)	65	65	63	62	1,686,000 ac-ft
Sinclair (MPR)	95	95	82	91	214,000 ac-ft
ALABAMA					
Lake Martin (P)	100	96	96	90	1,373,000 ac-ft
TENNESSEE VALLEY					
Clinch Projects: Norris and Melton Hill Lakes (FPR)	77	69	74	57	1,166,000 cfsd
Holston Projects: South Holston, Watauga, Boone, Fort Patrick Henry, and Cherokee Lakes (FPR)	88	86	70	64	1,452,000 cfsd
Douglas Lake (FPR)	85	83	59	64	715,800 cfsd
Hiwassee Projects: Chatuge, Nottely, Hiwassee, Apalachia, Blue Ridge, Ocoee 3, and Parksville Lakes (FPR)	88	85	83	77	523,700 cfsd
Little Tennessee Projects: Nantahala, Thorpe, Fontana, and Chilhowee Lakes (FPR)	93	94	83	81	751,400 cfsd
WESTERN GREAT LAKES REGION					
WISCONSIN					
Chippewa and Flambeau (PR)	93	94	94	87	15,900 mcf
Wisconsin River (21 reservoirs) (PR)	88	71	94	83	17,400 mcf
MINNESOTA					
Mississippi River headwater system (FMR)	40	36	37	41	1,640,000 ac-ft

Reservoir	End of May 1972	End of June 1972	End of June 1971	Average for end of June	Normal maximum
	Percent of normal maximum				
MIDCONTINENT REGION					
NORTH DAKOTA					
Lake Sakakawea (Garrison) (FIPR)	93	99	96	....	22,640,000 ac-ft
NEBRASKA					
Lake McConaughy (IP)	90	90	96	78	1,948,000 ac-ft
OKLAHOMA					
Keystone (FPR)	89	80	99	106	661,000 ac-ft
Lake O' The Cherokees (FPR)	94	96	99	94	1,492,000 ac-ft
Tenkiller Ferry (FPR)	97	91	92	98	628,200 ac-ft
Lake Altus (FIMR)	24	23	22	67	134,500 ac-ft
Eufaula (FPR)	86	78	93	88	2,378,000 ac-ft
OKLAHOMA--TEXAS					
Lake Texoma (FMPRW)	90	86	82	101	2,722,000 ac-ft
TEXAS					
Possum Kingdom (IMPRW)	97	96	68	84	724,500 ac-ft
Buchanan (IMPW)	96	92	72	83	955,200 ac-ft
Bridgeport (IMW)	87	78	66	70	270,900 ac-ft
Eagle Mountain (IMW)	92	92	89	92	182,700 ac-ft
Medina Lake (I)	100	100	43	50	254,000 ac-ft
Lake Travis (FIMPRW)	95	94	66	79	1,144,000 ac-ft
Lake Kemp (IMW)	41	43	23	58	461,800 ac-ft
THE WEST					
ALBERTA					
Spray (P)	36	86	71	56	210,000 ac-ft
Lake Minnewanka (P)	56	93	76	59	199,700 ac-ft
St. Mary (I)	75	81	89	92	320,800 ac-ft
WASHINGTON					
Franklin D. Roosevelt Lake (IP)	26	93	98	98	5,232,000 ac-ft
Lake Chelan (PR)	62	90	96	97	676,100 ac-ft
IDAHO--WYOMING					
Upper Snake River (7 reservoirs) (IMP)	72	97	97	90	4,282,000 ac-ft
WYOMING					
Pathfinder, Seminoe, Alcova, Kortes, and Glendo Reservoirs (I)	78	82	86	49	3,016,000 ac-ft
Buffalo Bill (IP)	38	96	103	104	421,300 ac-ft
Boysen (FIP)	68	101	104	89	802,000 ac-ft
Keyhole (F)	89	91	86	38	199,900 ac-ft
COLORADO					
John Martin (FIR)	0	0	0	23	364,400 ac-ft
Colorado–Big Thompson project (I)	83	95	97	73	722,600 ac-ft
Taylor Park (IR)	86	102	102	97	106,000 ac-ft
COLORADO RIVER STORAGE PROJECT					
Lake Powell; Flaming Gorge, Navajo, and Blue Mesa Reservoirs (IFPR)	56	61	56	....	31,276,500 ac-ft
UTAH--IDAHO					
Bear Lake (IPR)	92	98	97	67	1,421,000 ac-ft
CALIFORNIA					
Hetch Hetchy (MP)	51	90	99	81	360,400 ac-ft
Lake Almanor (P)	79	84	104	60	1,036,000 ac-ft
Shasta Lake (FIPR)	97	91	100	89	4,377,000 ac-ft
Millerton Lake (FI)	70	61	94	83	503,200 ac-ft
Pine Flat (FI)	54	51	74	68	1,014,000 ac-ft
Isabella (FIR)	22	21	43	43	551,800 ac-ft
Folsom (FIP)	97	97	99	93	1,000,000 ac-ft
Lake Berryessa (FIMW)	83	80	96	85	1,600,000 ac-ft
Clair Engle Lake (Lewiston) (P)	99	99	99	92	2,438,000 ac-ft
CALIFORNIA--NEVADA					
Lake Tahoe (IPR)	85	89	98	74	744,600 ac-ft
NEVADA					
Rye Patch (I)	98	98	99	54	179,100 ac-ft
ARIZONA--NEVADA					
Lake Mead and Lake Mohave (FIMP)	67	67	65	72	27,970,000 ac-ft
ARIZONA					
San Carlos (IP)	7	5	0	15	948,500 ac-ft
Salt and Verde River system (IMPR)	41	38	40	42	2,073,000 ac-ft
NEW MEXICO					
Conchas (FIR)	36	32	48	78	352,600 ac-ft
Elephant Butte and Caballo (FIPR)	7	7	8	29	2,539,000 ac-ft

[a] Thousands of kilowatt-hours.

NEW FLOOD-PLAIN MAP FOR THE LOGAN AREA, WEST VIRGINIA

The U.S. Geological Survey recently published a flood-plain map for the Guyandotte River in the vicinity of Logan, Logan County, in southwestern West Virginia. Logan is 10 to 15 miles north and west of the area disastrously flooded on February 26, 1972, as the result of the collapse of a coal-waste dam on a tributary of Buffalo Creek, which in turn is a tributary of the Guyandotte River (see abstract of report on the Buffalo Creek flood on the back page of this issue).

The new map delineates on a photomosaic base map, scale 1:6,000 (1 inch = 500 feet), areas inundated by floods of 5-, 25-, and 50-year recurrence interval on Guyandotte River in the vicinity of Logan. A brief text discusses the flood data, extent and depth of flooding, magnitude, profiles, and frequency of floods. The map report is entitled, *Floods on the Guyandotte River in the vicinity of Logan, Logan County, W. Va.*, by E.A. Friel and G.S. Runner: U.S. Geological Survey Hydrologic Investigations Atlas HA-347, 2 sheets, 1972. The report was prepared by the Geological Survey to further the objectives of the Appalachian Regional Commission. The hydrologic data presented are useful for an appraisal of the hazards involved in occupancy and development of flood plains along the Guyandotte River in the vicinity of Logan.

Atlas HA-347 (set of 2 sheets) may be purchased for $1.50 from the U.S. Geological Survey, Branch of Distribution, 1200 S. Eads Street, Arlington, Virginia 22202. There have been 159 flood-plain atlas reports published to date in the series of hydrologic investigations atlases, showing parts of 26 States and Puerto Rico. These reports were listed and their locations shown on pages 10 and 11 of the May 1972 issue of the Water Resources Review.

NEW PUBLICATIONS OF THE GEOLOGICAL SURVEY

The water-resources and hydrologic reports listed below are among those that have been published within recent months by the Geological Survey. They may be purchased at the prices indicated from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

WATER-SUPPLY PAPER:

Water for a rapidly growing urban community–Oakland County, Michigan, by F.R. Twenter and R.L. Knutilla: U.S. Geological Survey Water-Supply Paper 2000. 1972. 150 pages. $1.00.

PROFESSIONAL PAPERS:

A rainfall-runoff simulation model for estimation of flood peaks for small drainage basins, by D.R. Dawdy, R.W. Lichty, and J.M. Bergmann: U.S. Geological Survey Professional Paper 506-B. 1972. 28 pages. $0.40.

Vegetation of Prairie Potholes, North Dakota, in relation to quality of water and other environmental factors, by R.E. Stewart and H.A. Kantrud: U.S. Geological Survey Professional Paper 585-D. 1972. 36 pages. $0.60.

Summary of the hydrologic situation on Long Island, N.Y., as a guide to water-management alternatives, by O.L. Franke and N.E. McClymonds: U.S. Geological Survey Professional Paper 627-F. 1972. 59 pages. $0.65.

Geology and ground-water system in the Gila River Phreatophyte Project area, Graham County, Arizona, by W.G. Weist, Jr.: U.S. Geological Survey Professional Paper 655-D. 1971(1972). 22 pages. $1.75.

Hydrology of two small river basins in Pennsylvania before urbanization, by R.A. Miller, John Troxell, and L.B. Leopold, with a section on *Observations of stream fauna*, by Ruth Patrick and R.R. Grant, Jr.: U.S. Geological Survey Professional Paper 701-A. 1971(1972). 57 pages. $0.75.

Combined ice and water balances of Gulkana and Wolverine Glaciers, Alaska, and South Cascade Glacier, Washington, 1965 and 1966 hydrologic years, by M.F. Meier, W.V. Tangborn, L.R. Mayo, and Austin Post: U.S. Geological Survey Professional Paper 715-A. 1971. 23 pages. $2.50.

Channel movement of meandering Indiana streams, by J.F. Daniel: U.S. Geological Survey Professional Paper 732-A. 1971(1972). 18 pages. $0.35.

The story of the water supply for the Comstock, including the towns of Virginia City, Gold Hill, and Silver City, Nevada, by H.A. Shamberger: U.S. Geological Survey Professional Paper 779. 1972. 53 pages. $0.70.

FLOW OF MAJOR RIVERS DURING JUNE 1972

River and location	Drainage area (square miles)	Mean annual discharge through September 1970 (cfs)	June 1972					
			Monthly mean discharge (cfs)	Percent of median monthly discharge[1]	Change in discharge from previous month (percent)	Discharge near end of month		
						(cfs)	(mgd)	Date
St. Lawrence River at Lake St. Lawrence[2]	295,200	239,100	299,000	118	+3	311,000	201,000	28
Delaware River at Trenton, N.J	6,780	11,360	33,470	434	+79	33,700	21,800	30
Susquehanna River at Harrisburg, Pa	24,100	33,670	164,900	741	+150	145,000	93,700	30
Potomac River near Washington, D.C	11,560	10,650	46,900	633	+80	22,800	14,700	30
Altamaha River at Doctortown, Ga	13,600	13,380	6,900	99	-17	9,440	6,100	24
Tombigbee River near Coatopa, Ala[3]	15,400	22,160	3,562	62	-70	2,800	1,810	30
Missouri River at Hermann, Mo	528,200	77,480	70,080	72	-39	62,000	40,100	28
Ohio River at Louisville, Ky[4]	91,170	110,600	94,700	125	-29	313,100	202,400	28
Mississippi River near Vicksburg, Miss[5]	1,144,500	552,700	403,600	70	-60	442,000	286,000	30
Colorado River near Grand Canyon, Ariz	137,800	....	14,420	....	- 3	....	....	....
Columbia River at The Dalles, Oreg[6]	237,000	194,000	775,500	171	+34	....	....	....
Fraser River at Hope, British Columbia	78,300	95,300	382,000	172	+68	320,000	207,000	29

[1]Reference period 1931–60 or 1941–70.
[2]Records furnished by Department of the Army, Corps of Engineers, Buffalo District. Discharges shown are considered to be the same as those at Ogdensburg, N.Y., which is directly opposite Prescott, Ontario.
[3]At Demopolis lock and dam.
[4]Records furnished by U.S. Army, Corps of Engineers.
[5]Records of daily discharge computed jointly by Corps of Engineers and Geological Survey.
[6]Discharge (adjusted for upstream storage) determined from information furnished by Bureau of Reclamation, Corps of Engineers, and Geological Survey.

WATER RESOURCES REVIEW — JUNE 1972

Cover map shows generalized pattern of streamflow for June based on 22 index stream-gaging stations in Canada and 130 index stations in the United States. Alaska and Hawaii inset maps show streamflow only at the index gaging stations which are located near the points shown by the arrows.

Streamflow for June 1972 is compared with flow for June in the 30-year reference period 1931–60 or 1941–70. Streamflow is considered to be *below normal* if it is within the range of the low flows that have occurred 25 percent of the time (below the lower quartile) during the reference period. Flow for June is considered to be *above normal* if it is within the range of the high flows that have occurred 25 percent of the time (above the upper quartile).

Flow higher than the lower quartile but lower than the upper quartile is described as being within the *normal range*. In the Water Resources Review *normal flow* is defined as the median of the 30 flows of June during the reference period. The normal (median) has been obtained by ranking those 30 flows in their order of magnitude; the highest flow is number 1, the lowest flow is number 30, and the average of the 15th and 16th highest flows is the normal (median). The normal is an average (but not an arithmetic average) or middle value; half of the time you would expect the June flows to be below the median and half of the time to be above the median. Shorter reference periods are used for the Alaska index stations because of the limited records available.

Statements about *ground-water levels* refer to conditions near the end of June. Water level in each key observation well is compared with average level for the end of June determined from the entire past record for that well or from a 20-year reference period, 1951–70. *Changes in ground-water levels* unless described otherwise, are from the end of May to the end of June.

The Water Resources Review is published monthly. Special-purpose and summary issues are also published. In the United States, issues of the Review are free on application to the Water Resources Review, U.S. Geological Survey, Washington, D.C. 20242.

This issue was prepared by J.C. Kammerer, H.D. Brice, E.W. Coffay, and L.C. Fleshmon from reports of the field offices, July 14, 1972.

WEST VIRGINIA'S BUFFALO CREEK FLOOD: A STUDY OF THE HYDROLOGY AND ENGINEERING GEOLOGY

The accompanying summary, map, and graph are from the report, *West Virginia's Buffalo Creek flood: A study of the hydrology and engineering geology*, by W.E. Davies, J.F. Bailey, and D.B. Kelly: U.S. Geological Survey Circular 667, 32 pages, 1972. Circular 667 may be obtained free on request to U.S. Geological Survey, 1200 S. Eads St., Arlington, Va. 22202.

SUMMARY

On February 26, 1972, the most destructive flood in West Virginia's history swept through the Buffalo Creek valley in the southwestern corner of the State, 40 miles south of Charleston (fig. 1). Shortly before 8:00 a.m., a coal-waste dam collapsed on the Buffalo Creek tributary of Middle Fork releasing some 17.6 million cubic feet (132 million gallons) of water. The water passed through two more piles of coal waste blocking the Middle Fork to reach the Buffalo Creek valley floor. In its ½-mile run from the top of the coal-waste dam to the floor of Buffalo Creek, the large volume of floodwater dropped in elevation some 250 feet. The small settlement of Saunders, near the junction of Middle Fork and Buffalo Creek in the shadow of the lower coal-waste bank, was completely destroyed by the force of the water as were parts of the other 16 mining camps farther down the valley.

The 10- to 20-foot flood wave traveled through the 15-mile Buffalo Creek valley at an average speed of about 7 feet per second (5 miles per hour) and reached the town of Man at the mouth of Buffalo Creek on the Guyandotte River around 11:00 a.m. During those 3 hours (fig. 2), at least 118 lives were lost, 500 homes were destroyed, 4,000 people were left homeless, property damage exceeded $50 million and highway damage alone exceeded $15 million. Two months after the flood, seven people were still reported missing.

Between February 24 and 26, the National Weather Service measured precipitation of 3.7 inches in the general area of Logan County and Buffalo Creek. That amount of precipitation is about a 2-year rainfall; that is, southwestern West Virginia can expect precipitation to equal or exceed 3.7 inches in a 3-day period on the average of once every 2 years. Streams similar to Buffalo Creek in and around Logan County responded to the 3 days of precipitation with flows on the order of a 10-year flood; that is, a flow that can be expected to occur on the average of about once in a 10-year period. Following the failure of the coal-waste dam, flow in Buffalo Creek near Saunders jumped from less than a 10-year flood to a discharge about 40 times greater than a 50-year flood. The difference between the discharge less than a 10-year flood and the discharge 40 times greater than the 50-year flood reflects the difference between the natural flood that would probably have occurred and the flood that resulted from failure of the dam.

Employees of the Buffalo Creek Mining Co., operators of the coal-waste dam that failed, report that water was within 1 foot of the graded crest of the dam 4 hours prior to the flood. Failure of the coal-waste dam probably occurred through foundation deficiences, causing sliding and slumping of the front face of the dam. The failure was accelerated by the waterlogged condition of the dam. The slumping lowered the top of the coal-waste dam and allowed the impounded water to breach and then rapidly erode the crest of the dam. Upon failure of the dam, the floodwater moved into pockets of burning coal waste at the lower coal-waste bank and caused explosions. The only signs of burning and explosions were at the lower coal-waste bank.

In their coal-mining operations, the Buffalo Creek Mining Co. had built three major coal-waste banks by dumping waste rock and coal in the narrow valley of Middle Fork. Coal-waste bank No. 1 was located at the mouth of the Middle Fork. Banks No. 2 and 3 were upstream 600 and 1,200 feet from bank No. 1 and served as dams prior to the flood. Part of the purpose of the dams was to reduce stream pollution by impounding the waste-water from the coal washing plant, thus allowing most of the sediment to settle. The porous nature of the coal-waste dams allowed most of the water normally to filter through the dam and this clear water was recycled to the washing plant from decanting basins downstream.

Although banks No. 2 and 3 were not engineered as dams and would not be acceptable as dams in an engineering sense, they will be referred to as coal-waste dam No. 2 and coal-waste dam No. 3. Coal-waste dam No. 3 impounded the 17.6 million cubic feet of water that produced the flood. A fourth small bank, about 2,600 feet upvalley from dam No. 3, formerly served as an impounding structure, but the area behind it was filled with sediment in 1972.

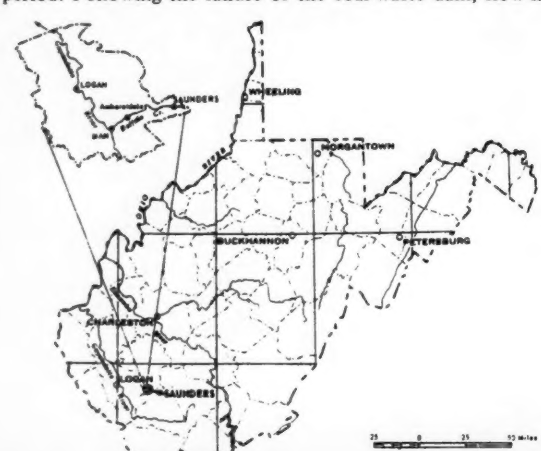


Figure 1.—Location of Buffalo Creek flood area.

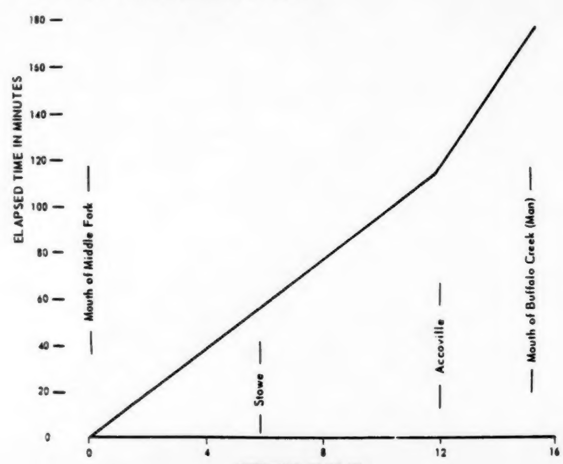


Figure 2.—Time of travel of the flood wave down Buffalo Creek from Middle Fork to Man.

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